Figure 1 Test Schemes and Conditions for VB and VisABC Processes

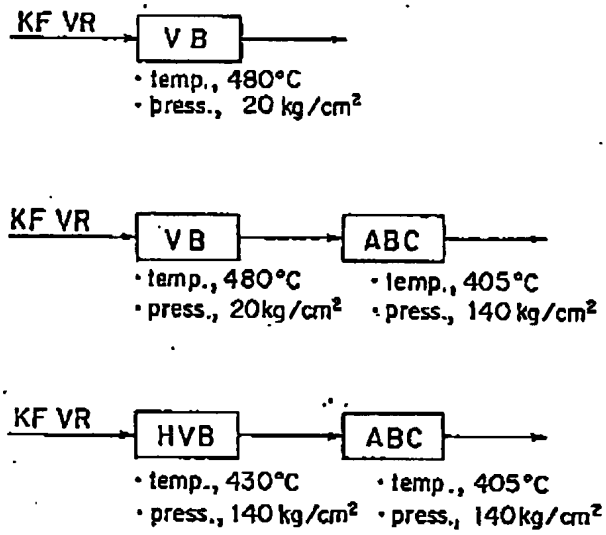

Figure 2 Distributions of Maltenes and Asphaltenes

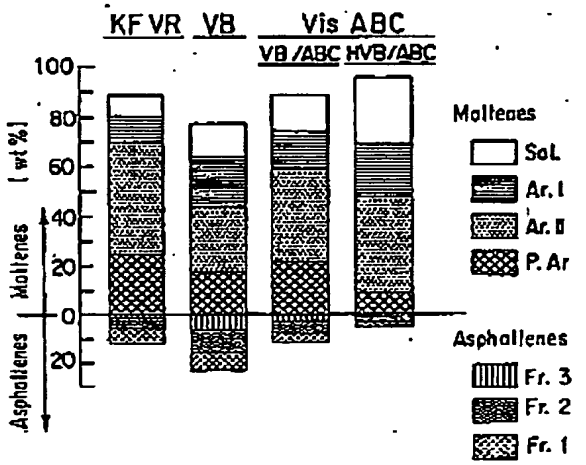

Figure 3 Possible Chemical Structures of Hydrocarbon Types from Maltenes

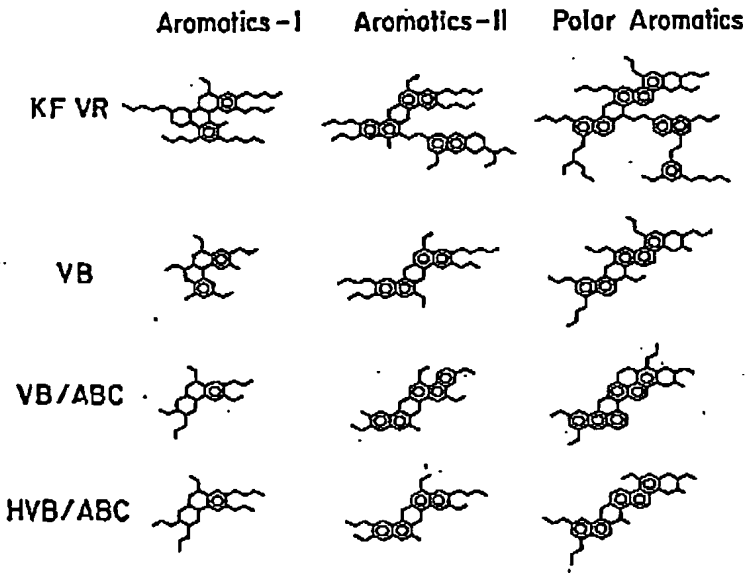

Figure 4 Possible Chemical Structures of Asphaltene Subfractions

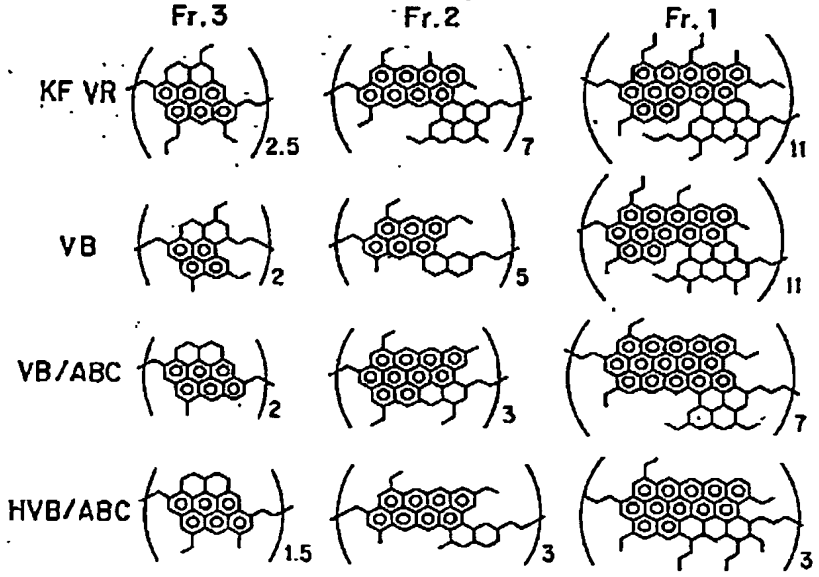

Figure 5 Conversion vs. Asphaltenes

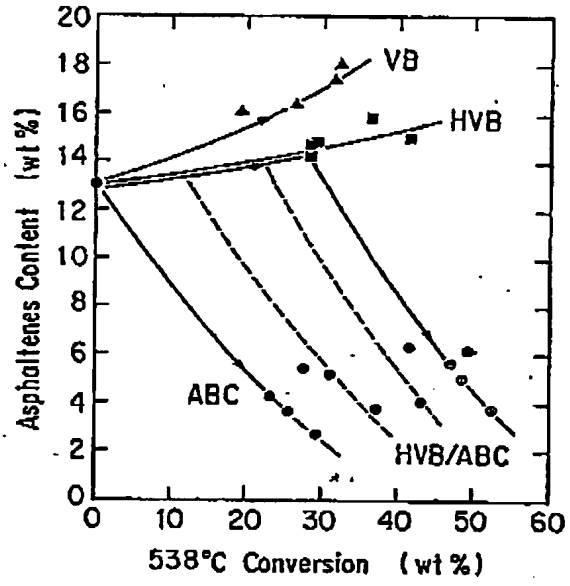

Figure 6 Conversion vs. Compatibility

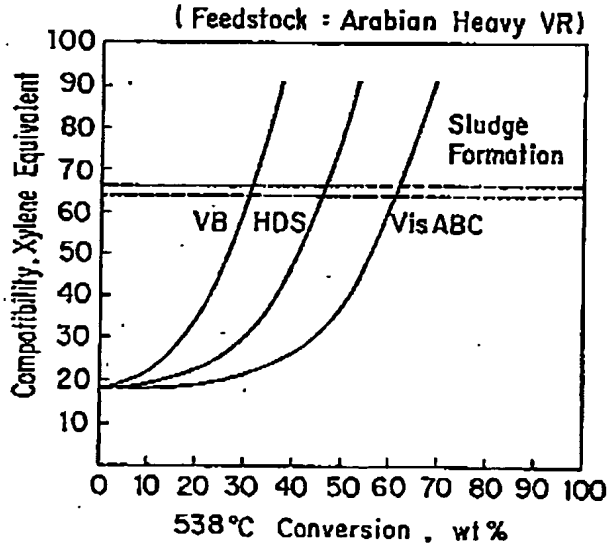

Figure 7 Flow Scheme of Vis ABC Process

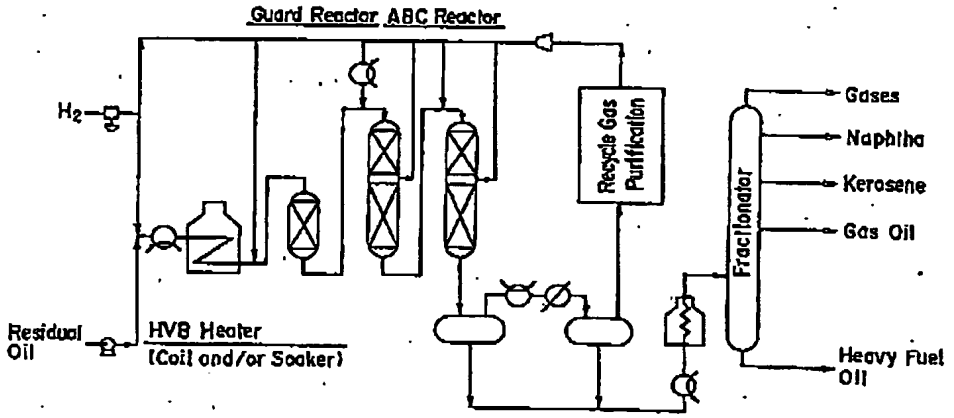

Figure 8 Refinery Flow Scheme for Upgrading Orinoco Heavy Oil

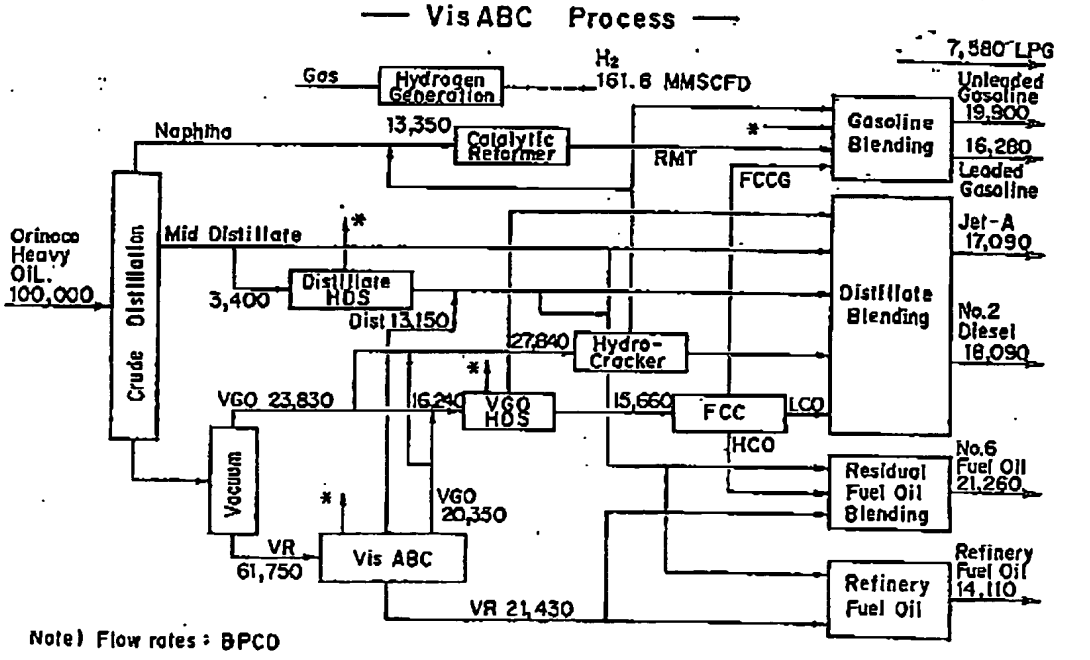

Figure 9 Magnitude of Residue Upgrading and the Economics of Refinery with Vis ABC Process

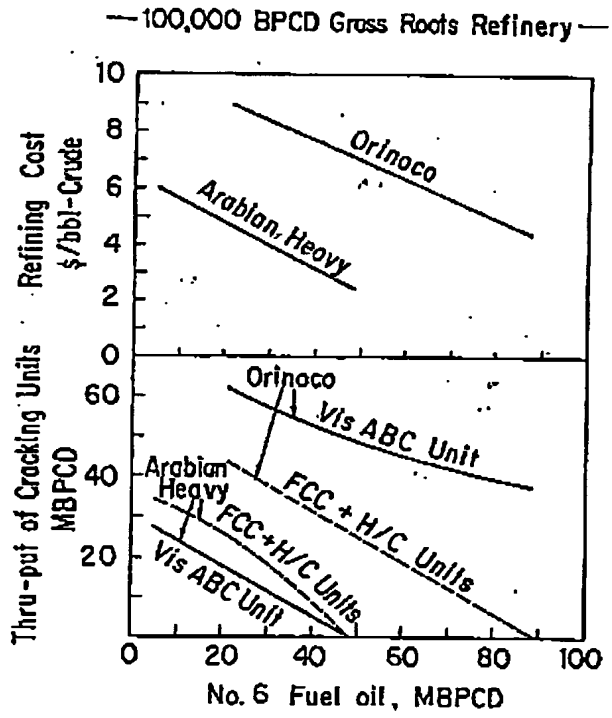

Table 1 Product Yields and Properties in Higher Temperature Operation of Commercial Resid HDS Unit with ABC Catalyst

Feedstock Properties			Product Properties		
Nominal Cut Point , °C		427	Naphtha		
Specific Gravity , d15/4°C		1.0038	Specific Gravity , d15/4°C		0.7200
Viscosity 650°C , cst		11,500	Sulfur , wt-ppm		40
Sulfur , wt%		4.18			
Vanadium , wt-ppm		136	Gas Oil		
Nickel , wt-ppm		40	Specific Gravity , d15/4°C		0.8506
CCR , wt%		16.2	Viscosity 650°C , cst		2.4
Asphaltene , wt%		7.0	Sulfur , wt%		0.05
Product Yields , vol%			Atm. Residue		
Naphtha		3.4	Specific Gravity , d15/4°C		0.9885
Gas Oil		18.4	Viscosity 650°C , cst		360
Atm. Residue		82.2	Sulfur , wt%		0.56
Total Liquid		104.0	CCR , wt%		8.02
Chemical Hydrogen Consumption , scf/bbl		1,139			
538°C Conversion , wt%		43			

Table 2 Characteristics of Arabian Heavy VR and Product Oils

				VisABC	
		A/H-VR	VB	VB/ABC	HVB/ABC
Viscosity , 650°C	(cst)	5,400[1)]	10,000	210	85
Specific Gravity , d15/4°C		1.0360	1.0255	0.958	0.9531
Asphaltene	(wt%)	13.1	15.5	7.89	4.38
Toluene Insoluble	(wt%)	Trace	Trace	0.01	0.01
CCR	(wt%)	23.3	25.3	16.9	12.8
H/C Atomic Ratio		1.038	1.399	1.485	1.591
Sulfur	(wt%)	5.25	5.04	2.21	1.76
V/Ni	(wt-ppm)	150/52	148/53	30/24	16/16
Thermal Stability		Stable	Stable	Stable	Stable
538°C Conversion	(wt%)	-	30	48	55

* 1) @100°C

Table 3 Product Yields and Properties with VisABC Process

	Orinoco Vacuum Residue		Arabian Heavy Vacuum Residue	
Feedstock Properties				
Specific Gravity, d15/4°C	1.0622		1.0360	
Viscosity @150°C, cst	2,270		380	
CCR, wt%	23.6		13.3	
Asphaltene, wt%	19.8		13.1	
Sulfur, wt%	4.28		5.25	
Vanadium, wt-ppm	640		150	
Nickel, wt-ppm	150		52	
Product Yields	wt%	vol%	wt%	vol%
H_2S	3.6		4.8	
NH_3	0.5		0.3	
$C_1 - C_4$	4.4		3.3	
C_5 - 190°C	10.9	15.1	5.6	7.7
190 - 260°C	8.8	10.1	6.8	8.2
260 - 343°C	9.4	11.2	9.8	11.6
343 - 538°C	29.8	32.8	34.0	38.1
538°C	35.2	38.7	37.2	37.9
Total	101.7	103.9	101.7	103.5
Chemical Hydrogen Consumption, scf/bbl	1,230		1,140	
538°C Conversion, wt%	60		60	

	Orinoco Vacuum Residue	Arabian Heavy Vacuum Residue
Product Properties		
C_5 - 190°C		
Sp.Gr., d15/4°C	0.760	0.750
Sulfur, wt%	0.01	0.003
190 - 260°C		
Sp.Gr., d15/4°C	0.837	0.839
Sulfur, wt%	0.01	0.01
Smoke Point, mm	15	16.5
260 - 343°C		
Sp.Gr., d15/4°C	0.891	0.874
Sulfur, wt%	0.11	0.06
Cetane Index, -	43	50
343 - 538°C		
Sp.Gr., d15/4°C	0.963	0.929
Sulfur, wt%	0.49	0.37
538°C+		
Sp.Gr., d15/4°C	1.077	1.016
Viscosity @150°C, cst	900	80
Sulfur, wt%	2.17	1.72
CCR, wt%	41.8	26.5
Vanadium, wt-ppm	371	75
Nickel, wt-ppm	117	45

Table 4 Study Bases

1. A grass-roots refinery to process 100,000 BPCD of selected heavy crude oils. Following alternative feedstocks are studied:
   (1) Orinoco Heavy Oil (Cerro Negro), 7.5°API
   (2) Arabian Heavy Crude, 28.2°API
2. Residual oil is converted to distillate products through the VisABC process followed by the FCC and/or Hydrocracker.
3. The production ratio between motor gasolines and middle distillates is set to be around 50/50 volume percent.
4. Specification on product qualities are on an international marketing grade.
5. Self-sufficient in utility supply.
6. Cost basis in 1984, U.S. Gulf Coast.

Table 5 Properties of Feed Crudes

Crude Name	Orinoco (Cerro Negro) *1)	Arabian Heavy
Gravity, °API	7.5	28.2
Sulfur, wt%	3.66	2.80
Metals, wt-ppm		
Vanadium	428	50
Nickel	108	17
Carbon Residue, wt%	16.9	6.7
Distillation, vol%		
IBP/180°C	0.0	21.0
180/260°C	4.0	13.3
260/343°C	10.4	12.9
343/538°C	23.8*2)	26.2
538°C+	61.8*3)	27.6

*1) Analyzed by Chiyoda *2) 343/482°C *3) 482°C+

Table 6 Product Yields from Orinoco and Arabian Heavy Crude

	BPCD		Product Specification
Feedstock	Orinoco	Arabian Heavy	
	100,000	100,000	
Marketable Products			
- LPG	7,580	10,010	Olefine = 5%
- Unleaded Gasoline	19,900	23,290	(RON + MON)/2 = 88.3, RVP = 10.1 Psia
- Leaded Gasoline	16,280	19,020	(RON + MON)/2 = 88.8, RVP = 10.1 Psia Lead = 1.1 g/Gal
- Jet A	17,090	21,110	Smoke Point = 20 mm Sulfur Content = 0.3 wt%
- No.2 Diesel	18,090	20,130	Cetane Index = 50 Sulfur Content = 0.5 wt%
- No.6 Fuel Oil	21,260	4,850	Viscosity @50°C = 638 cst Sulfur Content = 3.0 wt%
Total	100,200	98,380	
Refinery Fuel			
- Gas	691	1,120	
- Oil	14,110	9,420	Viscosity @50°C = 638 cst Sulfur Content = 3.0 wt%

Table 7 Economics for Upgrading Orinoco and Arabian Heavy Crude

	ORINOCO		ARABIAN HEAVY	
1. Capacity of Cracking Unit	BPSD		BPSD	
VisABC	69,000		31,000	
Hydrocracker	34,000		27,800	
FCC	17,000		12,500	
2. Investment Cost	MM$		MM$	
Process Units	537.1		369.9	
Offsite Facilities	286.0		241.4	
Catalyst & Chemicals	26.4		12.4	
Total	849.5		623.7	
3. Refining Cost	MM$/Year	$/bbl-Crude	MM$/Year	$/bbl-Crude
Catalyst & Chemicals	46.7	1.2	12.4	0.4
Labor	6.0	0.2	6.0	0.2
Maintenance	32.2	0.9	23.0	0.6
Insurance, Tax & Overhead	17.0	0.4	12.5	0.3
Capital Recovery*)	222.8	6.1	163.6	4.5
Total	324.7	8.9	217.5	6.0

*) Capital Recovery factor is set at 26.2% of investment which is calculated on the basis of :

- Tax Rate : 48%
- Required DCF Return : 15%
- Depreciation : 13 years of double declining balance